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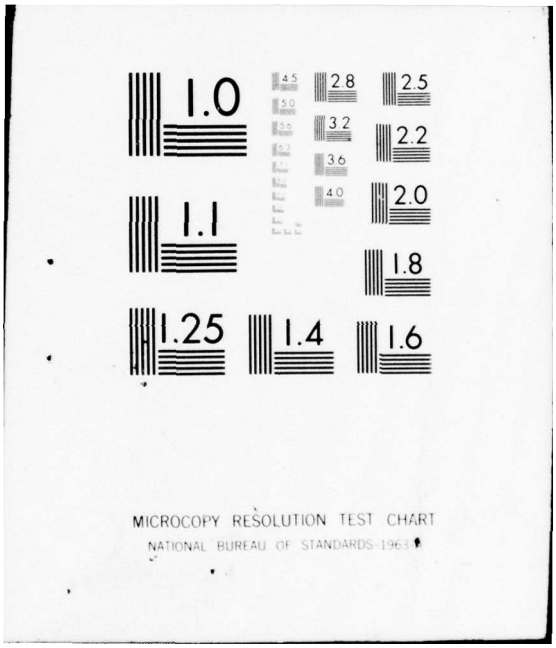
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DEFENSE SYSTEMS MANAGEMENT COLLEGE

PROGRAM MANAGEMENT COURSE
INDIVIDUAL STUDY PROGRAM

RIW - AN OVERVIEW OF PROPER APPLICATIONS AND ASSOCIATED RISKS WHEN APPLIED TO ELECTRONIC HARDWARE

STUDY PROJECT REPORT
PMC 77-2

Ronald David Schleder
CIVILIAN ROCKWELL INTERNATIONAL

FORT BELVOIR, VIRGINIA 22060

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DEFENSE SYSTEMS MANAGEMENT COLLEGE

STUDY TITLE:

RIW - AN OVERVIEW OF PROPER APPLICATIONS AND ASSOCIATED RISKS WHEN APPLIED TO ELECTRONIC HARDWARE

STUDY PROJECT GOALS:

To provide an overview of the Reliability Improvement Warranty (RIW). Included is a study of the RIW application criteria, contractor and Government risks and recommendations.

STUDY REPORT ABSTRACT:

This report is written as a overview of today's RIW concept. Included in the report is a brief history, guidelines for application, contractor risks, Government risks and recommendations which can minimize the risks for both parties.

The RIW concept is still relatively new at this point in time. Very little data exists which substantiates the RIW as being a viable warranty concept.

The risks, as viewed by the writer, must be shared by both parties. The correct structuring of the RIW contract requires careful consideration and evaluation by both the Government and the contractors.

The Government must encourage participation by contractors during the contract RFP phase to ensure maximum competitive pricing. If a competitive environment does not exist, it is likely that the Government will pay an excessive amount of money for RIW coverage desired.

As the recommendations in this report show, the risks can be assessed and managed. However, in the end, it will most likely be the ability of the Service Program Manager and the contractors ability to cooperate in a spirit of helpfulness and goodwill that makes the program succeed. No matter how well the contract language is written, it will be people that determine the final outcome.

KEY WORDS: RELIABILITY, WARRANTY, RIW, FIW

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RIW - AN OVERVIEW OF PROPER APPLICATIONS AND ASSOCIATED RISKS WHEN APPLIED TO ELECTRONIC HARDWARE

Study Project Report

Individual Study Program

Defense Systems Management College

Program Management Course

Class 77-2

by

Ronald David Schleder
Civilian Rockwell International

November 1977

Study Project Advisor
LTC Joseph Arcieri

EXECUTIVE SUMMARY

This report provides an overview of the Reliability Improvement Warranty (RIW) concept and its application to electronics systems/subsystems.

A new warranty concept began in the mid-60's when the Navy entered into a Failure Free Warranty, a forerunner of today's RIW, on the AJB-3 gyro used in the A-4 and F4 A/C.

RIW is successfully being used today by the Navy and the Air Force on many major electronic system programs. To a large extent, the key to this success is due to the ability of the Services and Industry to carefully select the equipment type that meets the requirements of an RIW concept. Equipment selection factors such as size, ability to be transported, capability of field testing and the ability to "seal" the unit to prevent unauthorized repair must be carefully evaluated to determine a systems suitability for RIW.

Once the system has been selected for an RIW application, the contractor should, during the design phase, perform the necessary engineering design tradeoffs which ensure his competitive position during the production bidding.

As in any business arrangement, both parties face significant but manageable risks when entering into an RIW agreement. The contractor must assess his risks in the area of costs which are determined primarily by the system Mean Time Between Failure (MTBF) and individual unit repair costs. The Government risks are centered around the pricing of the warranty, the administrative complexity of a new warranty system, contractor

performance and the transition to Government controlled maintenance at the end of the warranty period.

Although there are risks and problems involved, the RIW concept has exceptional merit when properly administered. The Service and the contractor must work as a team on the successful RIW in a spirit of cooperation. Both parties are working for the same goal, a more reliable system, and stand to gain significantly if the program is a success. Likewise, both will lose if they cannot work together toward a common goal.

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SECTION I

INTRODUCTION

A. Project Scope

This report involves the study and research of the relatively new warranty concept being applied by the Services. This warranty concept is called Reliability Improvement Warranty (RIW) by the United States Air Force and Failure Free Warranty by the Navy. This paper will refer to this warranty as RIW.

As is true in most acquisition strategies and contract structuring, differing philosophies as to the major risks involved and the outstanding issues which require defining was encountered during the study and data collection phase of this project.

This research report provides a historical background leading up to RIW as it is applied today by the Department of Defense (DOD) with particular emphasis on applications to electronic systems. Additionally, a general overview of RIW and guidelines for its correct application is presented.

Of prime consideration is the construction of the RIW contract in the proper format as to provide sufficient protection for the Government and the contractor alike.

From the facts developed from this study, recommendations as to the proper structuring of the typical RIW contract will be presented.

B. Definitions

Several definitions are presented to insure that there is a clear understanding of the major topics presented.

Warranty - As defined in the Armed Services Procurement Regulation (ASPR) 1-324.1

> A warranty is a promise or affirmation given by a seller to a purchaser regarding the nature, usefulness, or condition of the supplies or performance of services to be furnished. The principal purposes of a warranty in a Government contract are to delineate the rights and obligations of the contractor and the Government for defective items for a stated period of time or use, or until the occurrence of a specified event, not withstanding the contractual provisions pertaining to acceptance by the Government.

Reliability - The probability that an item will perform its intended function for a specified interval under stated conditions (14:4).[1]

Guarantee - A commitment embodying contractual incentives, both positive and negative, for the achievement of specified field operational goals (3:vii).

Reliability Improvement Warranty (RIW) - A fixed price commitment that involves contractor repair or replacement of defective equipment discovered during the period of coverage (3:vii).

Mean Time Between Failures (MTBF) - A measurement of reliability which is calculated by dividing the number of confirmed failures of a unit or system into some measure of usage such as hours, cycles, start ups, etc. This calculation provides the mean for the entire population.

C. Warranties - History and Background

Warranties for electronic equipment are certainly not new to the concept of acquisition in the military. Warranties in one form or another have been enforced on major acquisitions since the World War I days. In the past, most purchases of military electronic equipment included a warranty in accordance with the Armed Services Procurement Regulation (ASPR), paragraph 1,324 (2:vii).

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[1] Denotes the major references used throughout this report. The first number is the source in the bibliography, the second number is the page number.

The use of warranties have grown out of the commercial sector, for which the uniform Sales Act is a source of warranty-law principles (7:2-1).

Service warranties were written to provide protection to the procuring service by requiring the contractor to correct and subsequently prevent latent defects found in supplied hardware or material. The "standard" warranty period was one year or less. However, the one year warranty period often expire prior to the hardware item deployment due to the time it takes to process a new item through the service supply channels.

During 1959 the House Appropriations Committee (HAC) was concerned about the reliability of ballistic missiles and established a group of industry and National Bureau of Standards experts to review the Services' ballistic missile programs (14:6).

The task force, as established by HAC, presented a briefing to the Secretary of Defense and key ODDR&E officials in March 1960. This comprehensive briefing included: (14:7)

1. Nature of Reliability Problems
2. OSD Policy Responsibility in Reliability
3. Military Specifications and Reliability
4. Technical Requirements and Incentives for Reliability
5. Quality Control and Reliability
6. Summary of Recommendations Applicable to ASD/I&L
7. Recommendations of HAC on Missile Reliability

In the early 1960's it became evident that the philosophy of applying warranties similar to the commercial airlines left the military without the warranty coverage they desired, raising the question as to the value gained for the price paid.

In 1968 the Navy entered into the first contract which was the forerunner of today's Reliability Improvement Warranty (1:31). This contract was with Lear Siegler for repair of the AJB-3 gyro used in the A-4 and F-4 aircraft (1:31). This "new" concept had the unique approach of

requiring the contractor to provide the maintenance support for an extended period of five years.

Prior to this award to LSI the Navy was experiencing maintenance overhead costs of $3.44 per operating hour and an operational MTBF of 400 hours (1:31). At the end of the five year contract the cost of repair was reduced to $2.08 per hour and the MTBF was improved to 531 hours (1:31).

The intent of the services concerning warranties became crystal clear in a speech given in 1969 by the Air Force's Director of Procurement. In his speech the director stated:

> Now let's go to warranties. I am going to start with product warranties. Let me tell you, gentlemen, there's a warranty in your future, and it can take many forms . . . . There will be warranties on quality and reliability features as well. We are going to say, "Put reliability on the line and put your dollars and your reputation where your mouth is!" There are going to be more and more warranties as time goes on. Industry must stand behind its products and warranties are one way of getting that contractor support. We will get his attention as well (14:10, 8:24).

RIW is born!

SECTION II

OVERVIEW OF RIW

A. General RIW Provisions

A major consideration and concern with any contract is that it contain a set of provisions which are clearly understandable, defensable and can be adhered to by both parties. This criteria is an absolute must in the RIW contract.

The Reliability Improvement Warranty requires that, for a firm fixed price, the contractor will:

> Warrant that equipment and material furnished under the contract will be free from defects in design, material and workmanship and will operate in its intended environment in accordance with the contractual specifications (16:54).

RIW contracts will generally be written for an extended period of time, usually five years. During the warranty period, equipment that fails in the field environment is returned to the contractor for repair or replacement. When involved in an RIW contract, the contractor receives a fixed price, normally paid upon delivery of the electronic hardware. This one time fixed price covers all repairs and reliability improvement Engineering Change Proposals (ECP's) during the period of the warranty.

What's new and different about RIW is that it breaks down the old patterns that pit the contractor against the Government or visa versa (13:2). In RIW, there is a clear financial recognition that either both win -- i.e., better reliability saves operation and support costs and generates added profits -- or both parties lose --i.e., low levels of reliability reduce profits (13:2).

It is of prime importance to realize that RIW provisions can be wide ranging and vary greatly from one contract to another. Those detailed

provisions which, when written into a contract, tend to bind or minimize the risks for both parties, will be covered in another section of this report.

One of the primary differences in today's RIW is the application or absence of the MTBF guarantee. Because the MTBF guarantee is of major concern, it is described below and must receive serious consideration prior to the structuring of the RIW contract.

B. RIW/MTBF Contract

The MTBF guarantee, when used as an optional adjunct to RIW, requires the contractor to guarantee that a stated Mean Time Between Failures (MTBF) will be experienced by the equipment in the operating environment (2:vii). If the MTBF, which is guaranteed to increase during the RIW period (see figure 1.0) does not meet the contractual requirements, the contractor is required to take corrective action which corrects the causes of the "low" MTBF and may also be required to provide consignment spares until the MTBF guarantee is met (16:63).

C. Contractor Protection

Although the contractor is under obligation to make repairs on units that fail in the field environment, under certain circumstances the contractor has protection under the provisions of the contract. An example of the "exclusion" clause commonly used is shown below:

> The contractor shall not be obligated to correct or replace at no cost to Government any TACAN Set/Unit under these warranty provisions for nonconformance, loss, or damage by reason of (1) Non-TACAN induced fire; (2) Non-TACAN induced explosion; (3) Submersion; (4) Acts of God, such as flood, hurricane, tornado, earthquake, lightning, etc,; (5) Aircraft crash; (6) Enemy action; (7) Unit on which

seal[2] is broken outside contractors control. Included also are internal and external service induced damage or failures (16:54).

D. Summary

It cannot be overly emphasized that all RIW contracts must be written in such a manner as to provide risk coverage for both parties. The Government cannot be expected to enter into a warranty agreement whereby the coverage paid for is inadequate. Conversely, contractors cannot and will not enter into warranty agreements where the risks are undefined and cannot be sufficiently evaluated.

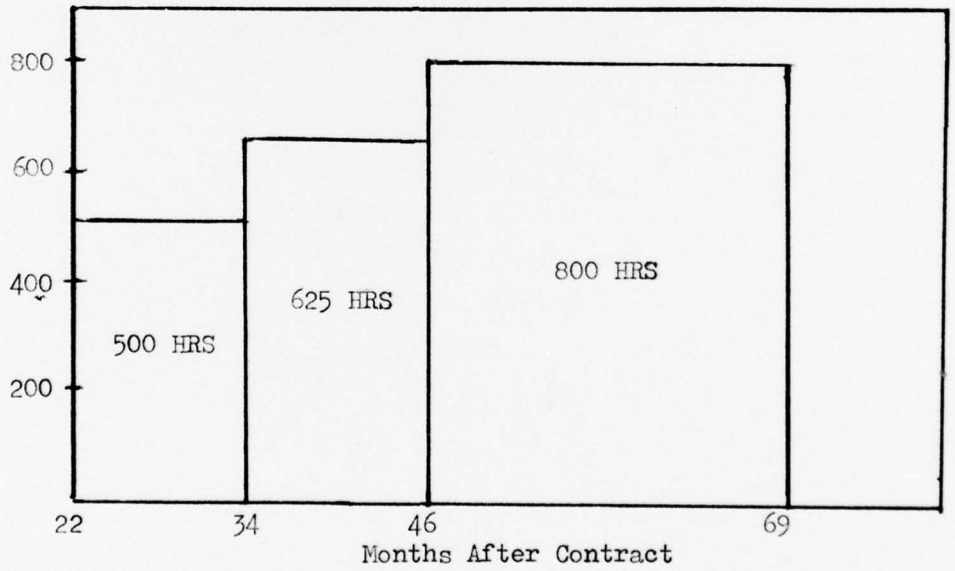

FIGURE 1.0

USAF TACAN SET AN/ARN 118(V) (F19628-75-C-0144) MTBF GUARANTEE

[2] Electronic "black boxes under warranty (RIW) are sealed by the contractor to prohibit internal access by service personnel.

SECTION III

GUIDELINES FOR APPLICATION OF RIW TO ELECTRONIC SYSTEMS

A. RIW - When does it make sense?

The decision to utilize an RIW contract in an Electronic Subsystem procurement is one of the major program decisions that will be made. The criteria governing the correct application of RIW has been given a considerable amount of consideration and study. Major studies have been conducted by DOD and Aeronautical Research Incorporated (ARINC) in a effort to insure that data is available which assists the program manager in the RIW/ No RIW decision.

The program managers decision to include a RIW clause in a procurement contract should not be made lightly since a proper approach involves a great deal of effort in structuring effective procurement, administrative and logistic provisions (1:38).

The properly applied RIW should have two favorable impacts on reliability; (1) during the critical development, design, and test phase of a program, RIW should provide the opportunity for a practical and achievable incentive to the contractor to build reliability and maintainability into the hardware and (2) after the equipment is operational, RIW should provide an incentive for continued reliability improvement (5:4,5). For these reasons, it is mandatory that the decision to include an RIW in a program be made at the earliest possible date in the initial planning phase.

As a general provision, RIW should not be applied to equipment already in the inventory which has achieved high, or acceptable, reliability under operational conditions as this would not prove to be economical (15:9). To carry this thought one step further, it may be difficult or uneconomical

to apply an RIW warranty to an equipment in the inventory which is not achieving accepted reliability. RIW, in the purest sense, should be a concept that is known and planned for in the development phase of the program. The contractor will, when involved in an RIW contract, perform certain trade-offs in initial design that may not occur if the RIW clause is not a part of the overall program.

Although there is an extensive list of criteria which must be examined to determine the applicability of an RIW, there are four individual conditions which the procured hardware must meet. If the hardware fails to meet any or all of the four criteria found in B below, the RIW contract will be plagued with extensive problems and is doomed to certain failure.

B. RIW Criteria - Four "musts" for electronic units.

1. The unit (hardware) must be reasonably self contained.

The RIW concept is based on the flexibility of replacing defective units quickly and efficiently on the flight line or similiar operational environments. The unit to be replaced must be self contained, rugged and easily installed or removed.

2. The unit must be "sealed" to eliminate or control unathorized maintenance in the field.

The RIW contract will, if structured correctly, contain an "exclusion" clause which will exclude a unit from being repaired at the contractor expense if unauthorized maintenance has been performed. The contractor will protect against unauthorized maintenance by "sealing" the dust cover and certain connectors with lead seals or a similiar technique. If the construction of a unit precludes the sealing of the dust cover and Avionics Ground Equipment (AGE) connectors,

the unit should be considered a poor canidate for RIW (3:3-5).

3. The unit must be readily transportable to the contractors facilities.

Generally the contractor will perform the repairs on failed units at his facility. This allows maximum usage of the contractors capital equipment as well as insures that repairs will be accomplished efficiently with particular emphasis on the quality of workmanship. Units involved in an RIW must be compact, rugged and capable of being boxed or packed for shipment in an efficient manner. Figure 2.0 demonstrates the amount of transportation that a typical avionics unit will be subjected to during a single "failure" cycle (16:57, 58, 58a, 58b).

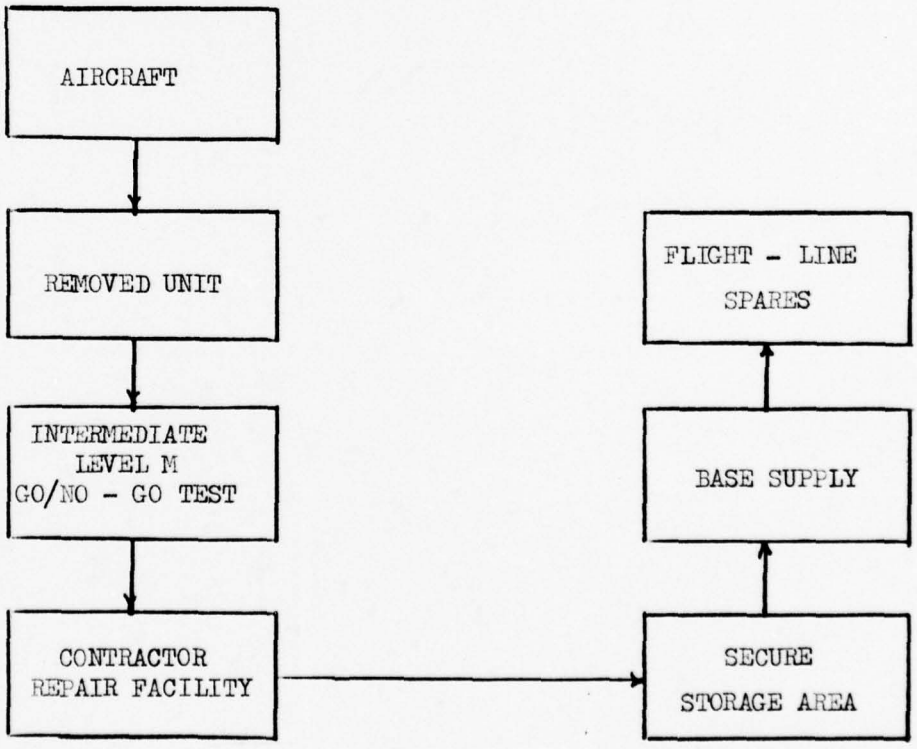

FIGURE 2.0

EQUIPMENT FLOW

4. The unit must be capable of being field tested.

Contractors will normally insist on a clause in the contract which protects them against excessive unit returns which are classified as non-verified failures. A non-verified failure is a unit which is returned to the repair facility as a failed unit, however, when tested at the repair facility the unit meets or exceeds the specifications. The clause which protects the contractor states that if the returned non-verified failure percentage exceeds a specified percentage the contractor is entitled to compensation. The contractor is not the only party interested in keeping the unverified percentage to a minimum, the user incurrs shipping and handling costs during the cycling of a unverified unit.

As explained, unverified failures are undesirable for both parties and a technique needs to be exercised to keep them to a minimum. The technique most often used is an abbreviated field test. This test, which should be part of the RIW contract, is a functional test which is designed to test those functions which give display information or provide voice communication to the pilot or operator.

The four "musts" described in this section are by no means all inclusive in the RIW decision. They are simply four criteria that must be met before further investigation into the applicability is made by the program manager.

C. Department of Defense Guidance

The Air Force published its Interim Guidelines Reliability Improvement Warranty (RIW) in July 1974. The application criteria stresses the importance of making the decision to use RIW early in the program. Early decision,

as mentioned previously, allow the prospective contractors to make the desired design trade-offs which are necessary for a sound RIW program. The following RIW criteria is presented from the Air Force document.

1. A warranty can be obtained at a price commensurate with the contemplated value of the warranty work to be accomplished with consideration being given to the contractually specified R&M requirements.

2. Moderate to high initial support costs are involved.

3. The equipment is readily transportable to permit return to the vendor's plant or, alternatively, the equipment is one for which a contractor can provide field service.

4. The equipment is generally self-contained, is generally immune from failures induced by outside units, and has readily identifiable failure characteristics.

5. The equipment application in terms of expected operating time and the use of environment are known.

6. The equipment is susceptible to being contracted for on a fixed price basis, with competition on the basis for form, fit and function stimulayed to the extent practicable.

7. The contract can be structured to provide a warranty period of from 3-5 years. This should allow the contractor sufficient time to identify and analyze failures in order to permit reliability and maintainability improvements.

8. The equipment has a potential for both reliability growth and reduction in repair costs.

9. Potential contractors indicate a cooperative attitude toward acceptance of a RIW provision and evaluation of its effectiveness.

10. A sufficient quantity of the equipment is to be procured to make the RIW cost effective.

11. The equipment is of a configuration that discourages unauthorized field repair, preferably sealed and capable of containing an Elapsed Time Indicator (ETI) or some other means of usage indication.

12. There is a reasonable degree of assurance that there will be a high utilization of the equipment.

13. The equipment is one that permits the contractor to effect no-cost ECPs subquent to the Government's approval.

14. Failure data and the intended operational use data can be furnished the contractor for the proposed contractual period and updated periodically during the term of the contract.

D. ARINC Guidelines

In June 1974 the Air Force awarded ARINC Research Corporation Contract F30602-74-C-0271 (3:v). This contract tasked ARINC to develop guidelines for determining where warranty plans can be effectively used, methods for evaluating the economic implications of their use and tasks required to implement warranty plans (3:vii).

The information shown below has been extracted from table S4, page xvii, of the ARINC report, Guidelines for Application of Warranties to Air Force Electronics System, published in December 1975. This information, which is divided into three major categories, Procurement, Equipment, and Operation, gives a very comprehensive listing of criteria to be considered when deciding if a particular unit or system is a candidate for RIW.

CRITERIA

Procurement

The procurement is to be on a fixed-price basis.

Multi-year funding for warranty services is available.

The procurement is competitive.

Potential contractors have proven capability, experience, and cooperative attitude in providing warranty-type services or LSC commitment.

The procurement quantity is large enough to make warranty economically attractive.

Analysis of warranty price versus organic repair costs is possible.

An escalation clause is included in the contract that is applicable to warranty or LCC costs.

The equipment will be in production over a substantial portion of the warranty period.

Equipment

Equipment maturity is at an appropriate level.

Control of unauthorized maintenance can be exercised.

Unit is field-testable.

Unit can be properly marked or labeled to signify existence of warranty coverage.

Unit is amenable to R&M improvement and changes.

Unit is reasonably self-contained.

Unit can be readily transported to the contractor's facilities.

Unit has high level of ruggedization.

Unit maintenance is highly complex.

An elapsed-time indicator can be installed on the equipment.

Operation

Use environment is known or predictable.

Equipment operational reliability and maintainability are

Equipment wartime or peacetime mission criticality is not of the highest level.

Equipment has a high operational utilization rate.

Warranty administration can be efficiently accomplished.

Duplication of an existing or planned government repair facility is not costly.

Unit reliability and usage levels are amenable to warranty maintenance.

Operating time is known or predictable.

Operational failure and usage information can be supplied to the contractor.

Backup warranty repair facilities are available.

Provision has been made for computing the equipment's MTBF.

E. Summary

The guidelines shown in this section are to be considered carefully when making the decision as to the RIW applicability of a particular unit or system. There are likely to be other considerations which pertain to particular systems which have not been mentioned in this paper. These criteria will also need careful consideration during the decision process. Few units or systems will meet every consideration shown. The intent is to present those considerations which have a major impact on the workability of an RIW contract. Trade-off decisions will normally have to be made during the decision process to insure a workable RIW contract. Remember, if the provisions can be clearly explained, the hardware designed to RIW concepts and the risks shared, RIW may be the lowest Life Cycle Cost approach.

SECTION IV

CONCERNS AND RISKS

A. CODSIA Concerns

In December 1975, a meeting between the USAF and the Council of Defense and Industry Associations (CODSIA) was held to discuss RIW. Brigadier General Dewey K. Lowe, Director of Procurement Policy, DCS/ Systems and Logistics Headquarter USAF, requested that the CODSIA members submit a report addressing the following four key issues:

Timing of RIW application
RIW Contracting Basis
MTBF Requirements
Failures

On March 5, 1976 the CODSIA report addressing the four key issues was sent to Brigadier General Lowe. The following discussion highlights the CODSIA concerns as expressed in the report of March 5.

CODSIA Concerns (5:2-25)

Timing of RIW application

The CODSIA report stated: "Industry is keenly aware of, and quite sympathetic with the USAF need for improved field reliability and feels that one route to the achievement of that goal may be a properly applied RIW program".

The report goes on to state that in today's environment 30% of the LCC spent on initial procurement and 70% on O&S. These facts make it obvious that the services cannot tolerate equipments with continued low field reliabilities.

The primary CODSIA concern is that an RIW may be applied to a equipment too early in the development and test cycle. CODSIA feels that the requirement for RIW quotations or options on production

articles prior to completion of the development cycle is an unsound procurement practice for both government and industry.

Rather than applying the firm RIW requirements so early in the development cycle, CODSIA recommends that a "meaningful incentive" (not penalty) should be tied to the accomplishment of an RIW cost goal (similar to a unit production cost goal) during the design/development/production cycle. In any event, states CODSIA, "the program must include extended development and reliability testing with adequate time and funds to accomplish this testing".

The report concludes the "timing" concern by stating: "A properly applied RIW should have two favorable impacts on reliability; (1) during the critical development, design, and test phase of a program, RIW should provide the opportunity for a practical and achievable incentive to the contractor to build reliability and maintainability into the hardware and (2) after the equipment is operational, RIW should provide an incentive for continued reliability improvement."

RIW Contracting Basis

The CODSIA report looks at two phases of the System Life Cycle, RDT&E and Production. It recognizes that there is a wide spectrum of contracts which provide the flexibility needed to procure the various DOD requirements. At one end is the firm fixed price type which is used when there are reasonably definite design or specific requirements and the costs can reasonably be determined and the contractor can therefore accept full cost responsibility (5:15). At the other end is the cost plus fixed fee type which is used when the uncertainties are of such a magnitude that costs cannot be estimated with sufficient reasonableness to insure an acceptable risk to

the buyer and seller (5:15).

During the design and development phase, CODSIA recognizes that new technology and new applications of existing technology carries with it a significiant amount of uncertainty. Because of this fact, the CODSIA group does not envision a change in the basic method of contracting for research and development with the advent of RIW. In part the uncertainties of equipment field performance, namely MTBF, during this phase necessitates the use of the cost reimbursement contracts (5:16).

In the Production phase of the contract, CODSIA continues to be extremely cautious on the application of a fixed price RIW. CODSIA contends that application of the fixed price RIW during the initial production places undue risks on the contractor as without field reliability data, he cannot reasonably predict the potential span of reliability growth (5:16).

CODSIA concludes its concern of contract types with the following recommendations (5:17).

a. The design and development cost reimbursable contract would appropriately contain a RIW goal with positive inventives to motivate the contractor to apply resources to the area of equipment reliability.

b. A limited number of production units, either under an extension of the development contract or an initial production contract would be used to acquired during this phase of the program would be utilized to structure the specific contract parameters thus reducing the risks for both the contractor and the Government.

MTBF Requirement

The thrust of the CODSIA report in the area of MTBF requirements is centered around the MTBF goal and its associated timing. In considering a contractual requirement for RIW, recognizing a competitive procurement, the Government should specify a MTBF goal (5:20). The MTBF goal should be set prior to the design/development stage and incentives should be applied to the meeting of that goal (5:20). CODSIA contends that the guaranteed MTBF (GMTBF) value should be set only after operational type testing has been performed on equipment similar to production hardware: and the final GMTBF value should be based on those tests.

Additionally, industry feels that if a GMTBF is to be used, the successive target approach, coupled with a high degree of contractor freedom in introducing changes during the successive measurement periods, is the most productive one for both industry and government (5:21).

Failures

What constitutes a failure? When is the contractor liable? The CODSIA report defines a failure as "any departure from the required performance in excess of the allowable tolerances defined in the equipment configuration item specification due to its own internal failure".

CODSIA also contends that the contractor should not be obligated to correct, replace or propose ECP actions at no cost to the Government with respect to any hardware item under RIW nonconformance, loss, or damage by reason of:

a. Fire
b. Explosion

c. Submersion
d. Flood
e. Aircraft (vehicle) crash
f. Enemy action
g. Seal broken on unit while outside contractor's control
h. External physical damage caused by accidental or willful mistreatment
i. Internal physical damage caused by accompanying external physical damage due to mistreatment or to tampering by non-contractor personnel
j. Act of God
k. Induced failures. Failures of hardware items induced by malfunction or improper operation of outside (system interfacing) units
l. Consequential/incidental damages
m. Unverified failures (i.e., the item "retest okay")
n. Improper installation/operation/or maintenance
o. Having been designed or developed or produced by others than the warrantor.

Note - the above "exclusions" will be repaired under a seperate exclusions contract.

A failure for which the contractor is responsible should be verified utilizing a test procedure which has been agreed upon by both the Government and the contractor (5:25). By utilizing this test procedure, non-verified failures will normally be found in the field environment which saves money and time for both parties.

B. Contractor Risks

Since American industry has the primary function of ensuring that the corporation receives a fair return on investment, costs are the primary risk involved in entering into the RIW agreement. Almost everything the contractor does during the RIW period effects costs, which directly impacts profit, either favorably or adversly. Due to the interrelationship between the RIW conditions and associated costs, it is relevant to address the RIW conditions and their individual impact on the overall costs.

The risks, as viewed by the writer, will be addressed in two seperate categories, major risks and other risk factors. The major risk category

will provide an insight into each risk as to its effect on costs and overall program ramifications. The "other risk factor" category is a broad brush view of "minor" risks which should also be assessed before and during the RIW performance period.

The major risks which are analized in this paper are:

1. Frequency of unit repair
2. Cost per unit repair
3. MTBF Guarantees
4. Repair turn-around-time
5. Equipment operating environment
6. Tampering or mishandling
7. Equipment usage (time)
8. Outyear costs

Major Risk Analysis

1. Frequency of unit repair

The contractors ability to correctly price and bid is obviously a critical factor when contracting for an RIW program. Many separate events and factors have significant impacts on determining correct pricing. One of the most important factors is the frequency of unit repair. By frequency of unit repair, we are referring to how many times during the RIW period one single unit will be returned for warranty repair.

The contractor will find this data extremely hard to calculate and even more difficult to obtain top management approval. The data as collected by the contractor is composed of the "history file" (field data for similar equipment types) and chamber data (stress testing in a field simulated environment). This may seem on the surface, as a relatively sound and accurate technique for predicting field reliability. It is, however, even at its best, a "ball park" answer which leaves many top executives extremely uncomfortable during the initial two or three years of the warranty period.

Reliability Engineers are hard pressed to agree on the conversion factor to be used when calulating field reliability from chamber reliability (6).

The writer's experience on this subject has spanned a wide gamit of equipments with equally wide ranges in correlation. On one end of the spectrum is equipment which reflects .25 hours of field reliability for every 1.0 hours of chamber time, on the other end of the spectrum is equipment which displays 2.0 hours of field reliability for every 1.0 hours in the chamber.

One problem with converting chamber hours to field hours is the correlation of the chamber environment to the actual usage environment once the equipment is introduced into the fleet.

Since a major portion of the contractor costs directly relate to the labor and parts expended during the actual repair of failed unit, the ability to predict the total number of returns during the RIW period is of paramount importance. If the contractor cannot get a handle on this parameter, his risk is unknown and he may be headed for disaster.

2. Cost of repair

The ability to project the cost of repair is based on the complement of parts/components which are designed into the equipment. Since in most cases, components being designed into the equipment are not new technology, the cost of repair should be accurately forecasted.

There are, however, risks involved with forecasting the cost of repair. Perhaps the biggest problem in this category is due to the current solid state technology being utilized on all new electronic designs. The solid state devices (semiconductors) being utilized

today are manufactured in lots or groups. It is quite possible that a particular lot of semiconductors can be defective and this defect not show up during the electronic equipment manufacture and testing. This phenomenon often occurs during the semiconductor manufacturing cycle due to process parameters varying slightly. During a high rate manufacturing contract, several hundred electronic units can be manufactured and sent to the field before the latent defect in the semiconductor surfaces. The costs of recycling several hundred additional units through the repair facility puts an enormous amount of stress, pressure and additional costs on the facility as it is manned and organized for a particular level or range of business.

3. *MTBF Guarantee*

The RIW contract that includes and MTBF guarantee requires the contractor to predict the initial field reliability (MTBF) and a reliability growth curve over the several years of the warranty coverage.

The ability to predict the MTBF of a newly introduced electronics system is a matter of considerable debate. Once again, Reliability Engineers have a considerable base from which they can draw to predict a systems reliability growth curve. Even so, predicting of MTBF's still has many mysteries, if this were not the case, why would the users need RIW and other types of warranty protection.

The major risk for the contractor when considering the MTBF guarantee is in the area of costs and reputation. The RIW contract which incorporates an MTBF guarantee will usually require the contractor to supply additional spare units to the field to ensure that sufficient operational systems are available for the using commands.

Additionally, the contractor is required to perform the required "Corrective Action" to correct the causes of the low MTBF. This "corrective action" will be performed on all newly manufactured systems as well as those in the Service inventroy.

The impact of lower than guaranteed MTBF can have a major impact on the contractors ability to make an adequate return on his investment as he will be forced to expend resources which were neither bid during negotiations or planned for in the annual operation plan. In most all of these cases, the contractor has no method of recovering the associated costs and can be in a loss position if the quanity of systems in the field approaches 25% or more of the total contract quanity when and if a major failure mode surfaces.

4. Repair turn-around time

The repair turn-around time measures the contractors ability to verify, correct, and retest a failed Line Replaceable Unit (LRU) and return it to the Government Bonded Storage Area.

The major risk associated with repair turn-around time is that, in most cases, the contractor is not organized or equipped to give failed units immediate attention through the entire repair/modification process. On the Air Force contract for TACAN 118(V) systems the repair turn-around time from "dock to stock" is 15 days maximum (16:59). On this contract, if the contractor does not meet an average of 15 days or less on repair turn-around time during a six month measurement period he will be required to pay the Government $25/day for every unit that completed repair during the measurement period.

Example:
250 units repaired during a 6 month measurement period
17 days = average repair turn-around time for measurement period
15 days = maximum TAT
$25/day penalty

17 days (actual)
15 days (contract maximum)
2 days x 250 units x $25 = $12,500 total penalty for measurement period.

Figure 3.0 illustrates the magnitude of a typical repair cycle for a electronic LRU.

RIW VERIFIED FAILURE - REPAIR CYCLE

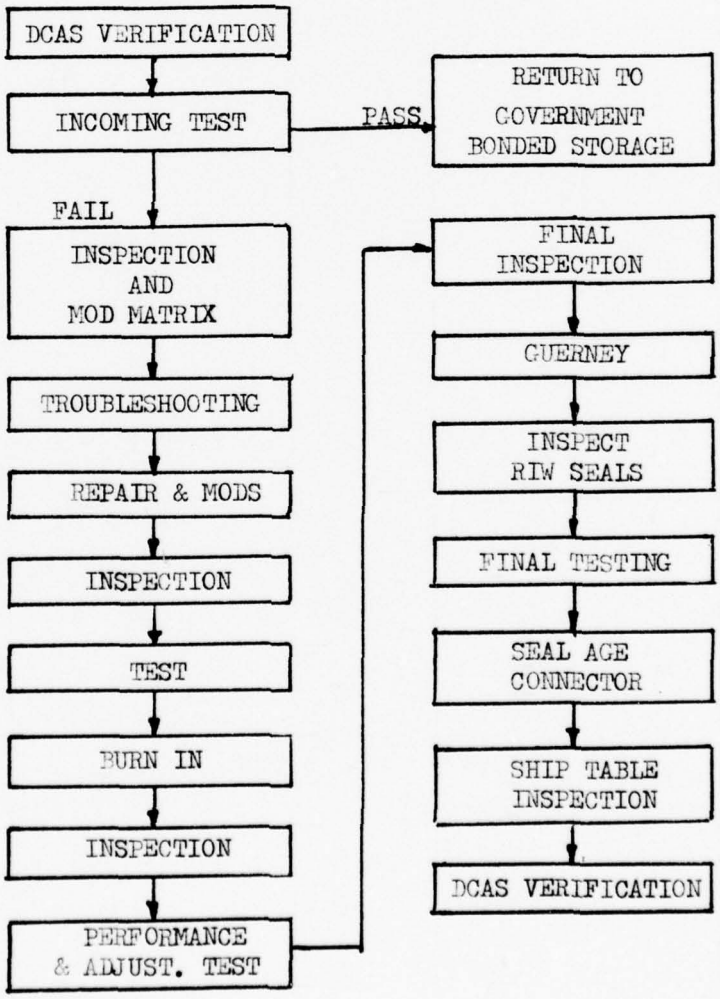

FIGURE 3.0

5. Equipment Environment (usage)

The reliability of a given electronics system is greatly dependent on its exposure to various environments. For this reason, it is exceedingly important that the user correctly define the environment and the environment profile for a system being contracted with an RIW clause. This task becomes extremely difficult when procuring a system which will be retrofitted to the entire fleet as well as utilized on "new" systems.

The variety of mission profiles, aircraft (bombers vs fighters) and environments makes the contractors job extremely difficult as he must design to meet the stated requirements and still stay in the competative arena.

6. Tampering or mishandling

As discussed in the "Cost of Unit Repair" section of this paper, the contractor must be able to correctly predict the cost to repair returned units.

The costs to repair a mishandled unit which has been damaged or one that has had unauthorized field repairs will usually be considerably higher than orginally planned for. Another risk occurs when electrical or temperature overstress is applied to the system or a particular system LRU.

Techniques are available which can reduce the risks of tampering and mishandling. These techniques are discussed in the "Recommendations" section of this report.

The electrical overstress problem is one risk that the contractor will continue to assume. Electrical overstresses are extremely difficult, if not impossible, to pinpoint unless an obvious overload

has been applied which burns printed circuit boards and electrical components.

7. Equipment usage (time)

As discussed earlier, a major portion of the contractors costs associated with an RIW contract are predicated on the number of units returned for warranty repair. The number of repairs is greatly dependent upon the system MTBF which, of course, is simply a measurement of failures in a given number of hours. The lower the MTBF, the higher amount of returned units and thus lower profits for the contractor. Some level of protection must be written into the contract and a method of determining the equipment usage hours built into the units. Without a "handle" on usage hours/month, the contractor cannot bid a firm fixed price RIW contract as he cannot totally assess all the risks involved.

8. Outyear costs

Because RIW contracts are written covering several years (usually 3-5 years) the outyear costs become an extremely significant factor. The contractors ability to accurately predict the long range economic trends is no better or no worse than anyone elses. As we all know, the ability to accurately predict the outyear economic situation has certainly been less than exacting during the past ten years. Contractors face the same uncertainity looking ahead as we now know existed in recent years. Before entering into an RIW agreement, the wise contractor will insist upon contract clauses which allow for abnormal cost growth.

Other Risk Factors

The contractor faces other risk factors which are important

even though they are not in the same category as those discussed earlier. These risks are considered minimal and consistent with the risks generally experienced by the contractor during his everyday business routine. The listing of risks in this section is provided for general consideration prior to entering into an RIW agreement. The following information has been extracted from ARINC report "An investigation of contractor risk associated with RIW" (2:xi).

General Factors

Factor	Risk Aspect
Warranty Obligation	Unless contractor's obligations under the warranty are clearly defined, the scope of his risk cannot be estimated.
Warranty Notification	Late notification of the intent to use warranty can be detremental.
Design Constraints	Detailed specifications of the item design can seriously affect warranty risk by reducing design and modification flexibility.
Design Innovation	Degree of new technology incorporated into an item can affect the inherent risk.
Item Reliability	Reliability of the warranted item is the principal factor in determining the scope of contractor cost risk.
Foreign Military Sales	Diversion of warranted and items to FMS customer may increase the contractor's risk under the warranty because of reduced knowledge concerning equipment usage and limited leverage.

Failure-Type Factors

Factor	Risk Aspect
Failure Definition	For the purpose of contractor repair liability and/or MTBF measurement, it is necessary to define a failure within the context of the warranty.

Unverified Failures	Contractor may receive items for warranty service that are determined to be serviceable.

Maintenance and Operational Factors

Factor	Risk Aspect
Maintenance Test Concepts	The utility and capability of test concepts designed for the item can affect warranty performance.
Warranty Data System	Effective warranty administration by the contractor depends on having good data records. Such records can be useful in identifying early trends, lead-to problem identification and risk reduction.
Transportation Costs	Cost of transporting the item between the point of use and repair center can be a significant cost factor. Often, at the time of bidding, quantities and location of warranted equipment are not known.
Misdirected Items	Sending to the contractor material that is not under warranty will increase his handling costs.

Contractor In-Plant Factors

Factor	Risk Aspect
Bonded Storeroom	The Government may desire that the contractor store servicable items in a controlled area at his plant. Storage requirements can become excessive if units are not installed in a timely manner. Excessive handling can occur in the event of high unverified failure rates.
Product Improvement	Contractor may desire to improve item reliability or maintainability to reduce his warranty costs but may not receive expeditious approval.
Material Rights	Contractor cost or efficiency of repair can be affected unless provision is made for expeditious exchange of modules and components.

MTBF Guarantee Factors

Factor	Risk Aspect
Operate-Time Measurements	Under typical terms of the basic RIW as well as RIW with MTBF guarantee, accurate estimates of the aggregate operate hours of all installed units are required. Often some type of sampling procedure has to be used.
Mean Time to Removal	A guarantee made on the basis of mean time between removals could be difficult for the contractor to price realistically since he has limited control of field maintenance actions.
Consignment Spares	As a penalty under terms of the MTBF guarantee or the turn-around-time requirements, consignment spares may be required. Provision of these spares represents a significant cost factor.
Consignment Spares Disposition	Consignment spares remain the property of the contractor and represent significant assets. Provision must be made to return these items in a timely manner when the contractor's obligation is complete.

C. Government Risks

The assumption of risks in an RIW agreement is not a one way street with the majority of the risks being that of the contractor. Risk sharing is the "name of the game" when it comes to a successful RIW program and the Government also has risks when entering into this type of an agreement.

When two parties enter into a business agreement, one party has a product or service to offer that the second party needs or requires. So also is the case with RIW, both parties are looking toward the business arrangement for distinct benefits. The contractor expects a fair return on investment coupled with reasonable risks and the Government has a right to assume a fair price paid for goods or services that meet or exceed the contract requirements.

Perhaps the largest and most important benefit for the Government is that the maintenance portion of the Life Cycle Cost becomes predictable and manageable.

Given that RIW is not all roses for either party, the risks assumed by the Government are significant and must be evaluated closely prior to the awarding of an RIW contract. The Government risks as viewed in this paper are:

1. RIW price
2. Equipment design
3. Administrative complexity
4. Transition
5. Contractor performance

Government Risk Analysis

1. RIW price

The benefits to be derived from use of an RIW provision should be related to the cost thereof to the Government as well as to system reliability and available. In the case of new systems and equipment entering the Government inventory, which are not similar to the existing equipment, the Government has no direct experience with such items for baseline cost (15:12).

Due to the lack of a baseline cost the Government runs the risk of paying an excessive amount of money for the warranty repairs to be performed during the RIW period. The negotiated price for any RIW contract are, of course, based on several cost factors. Two major cost factors are: (1) total number of unit failures which occur during the warranty period and (2) cost of repair per individual failure. To a certain degree, the Government as well as the contrator "wins" whenever the number of failures is less than the anticipated quanity as this results in decreased aircraft down time and increased

system MTBF.

The problem arises when the actual number of failures is far less than the anticipated number of failurs and it becomes obvious that the price paid for the warranty coverage far exceeds any actual or planned expenditures by the contractor. This situation increases the Life Cycle Cost of the system beyond the level planned or budgeted for at a time when maximum efforts are being directed at reducing and controlling LCC.

2. Equipment design

It is generally accepted that to be effective, the decision for RIW application should be made as early as possible in the acquisition cycle (15:9). When the contractor knows early in the design phase that there will be RIW requirements, he will make certain important design trade-offs. Although these design trade-offs will enhance the contractors ability to repair and/or mollify the units during the warranty period, they may not be appropriate or totally compatable with military maintenance concepts (2:1-4).

The placing of constraints and design limits on the contractor during the design phase of a system which will be involved in an RIW, is in direct contradiction of the generally accepted practice of "contractor latitude" during the design and development phases. The risk to the Government is that at the end of the warranty period, a system may be introduced into the maintenance environment which causes unusual delays, confusion and excessive costs.

3. Administrative complexity

Simply stated, RIW is not the typical method of performing the maintenance function in the Services. The RIW concept introduces a

totally new set of problems into the already complex field of military maintenance.

The problems associated with the introduction of a new concept into a well structured and disciplined maintenance program should not be taken lightly or underestimated. When RIW is introduced, people must adjust to a totally new way of doing their job. While they must adjust their method, procedures and habits for RIW, the remaining portion of their work remains unchanged. Essentially, we have introduced into the main stream of activity, a maintenance concept totally outside the "norm" which must receive special handling and attention if it is to have any chance at all to exceed.

4. Transition

At the end of any given RIW period, the Government is faced with two basic options. The first option is to renew the RIW contract with the contractor through negotiation. This assumes that the contractor is willing to negotiate and a satisfactory agreement can be reached. The second option is to assume the maintenance responsibility and introduce the system into the normal maintenance flow. The problems related to either of these options should not be minimized or taken lightly as explained below:

Option 1, Renew RIW

The equipment, at this point in time, is approximately five years old. Depending on the design, environment and complexity, the equipment may be getting to the point in its life cycle where the MTBF is being reduced due to the wear out factors. The contractor as well as the Government will be hard pressed to accurately forecast the average cost of an individual repair and the MTBF of the system for a period of one or more years. These factors make the decision to renew the RIW contract very risky for both parties and in all likelihood will cause this option to be ruled out.

Option 2, Assume Maintenance Responsibility

The problems associated with the Government assuming the maintenance responsibilities at the end of a five year RIW period are fairly involved. Among the questions that need answering are: (1) Where does the support test equipment come from? (2) What level of spare components and modules are required? (3) Is the technical data available and up to date?

Answering these three questions does not impose, by any means, an impossible task. However, answering these questions and providing the required facilities, spare parts procedures and test equipment does take a considerable amount of planning and time. If planning is not accomplished in a timely manner, the systems effectiveness can be greatly hampered during the transition phase.

5. Contractor Performance

Allowing contractors to perform all the required maintenance on an electronic system places the Government in a unique position. No longer does the Government control the critical function of maintenance which to a large extent determines the readiness and effectiveness of a major weapons system. The contractor now controls the maintenance process which includes (1) quality of work performed, (2) quanity of work performed, (3) Mean Time To Repair (MTTR) and, (4) the Government storage facility or warehouse. For these reasons, the overall performance of the contractor during the maintenance process must be extremely visible and closely monitored by the "in-plant representive" as well as the Services Program Manager. Failure of the contractor to perform can be devestating just as the failure of the Government to foresee the problem early on will cause the system in the field to quickly become ineffective.

D. Summary

This section of the report has outlined the problems and risks which both parties face when entering into a RIW agreement.

It quickly becomes strikingly clear that the RIW concept is not a panacea or a "cure all" for the maintenance problems of the past, present, and future.

It should also be made clear that, although there are problems associated with RIW, it can be an effective and useful tool in the management of a weapon system procurement. There are methods and techniques which tend to bind or minimize the risks for both parties during the warranty period. As the RIW concept grows, new and more effective contract language will be forthcoming which will enhance its ability to be accepted and administered.

SECTION V

RECOMMENDATIONS

The recommendations contained in this section are not necessarily new and many of them are currently being utilized on the TACAN Set AN/ARN 118(V) Contract which is being produced by Collins Government Avionics Division for the USAF.

Contractor Risks	Recommendations
• Frequency of unit repair	The contractor must be appraised that an RIW will be involved during the initial phase of the program so the appropriate engineering tradeoffs can be made. Additionally, the contractor should, on his own, perform extensive testing of prototype units to determine the design changes required to meet the MTBF requirements of the contract.
• Cost per unit repair	This analysis is accomplished by examining the failure rates of the components utilized in the design. Tradeoffs should be made during the design phase which will determine the level of component screening, unit burnin temperatures and chamber time as well as assembly, inspection and test procedures. One additional source of valuable information can be obtained from the companies warranty files. Equipments of similar design being utilized in an environment consistent with the item in question can be extremely valuable and should not be overlooked.
• MTBF Guarantees	MTBF Guarantees tend to cause most contractors extreme concern. Meeting MTBF Guarantees can be extremely difficult if the appropriate engineering design tradeoffs were not accomplished. One method to ensure that a realistic MTBF exists is to negotiate a postponement of the actual requirement until the qualification testing is accomplished. A goal can be announced during the development phase and a firm guarantee established after the qualification and reliability testing is

completed. In this situation price associated with the MTBF will be negotiated after the completion of testing and establishment of the MTBF requirement.

- Repair turn-around-time (TAT)

To ensure that the contractor consistently meets or exceeds the contractual repair turn-around-time the following steps should be taken.
1. Establish a repair facility totally dedicated to the RIW effort.
2. Provide an organization solely dedicated to the successful management of the RIW facility.
3. Establish a management information system which provides real time information on spare parts leveled, average unit TAT for the measurement period and unit repair costs.
4. Establish a direct communication line between the repair and the manufacturing facilities to ensure maximum information exchange.

- Equipment operating environment

The contract must be specific as to the mission profile of the system. Temperature extremes, Fighter vs Bomber Mix, and storage environment are examples of specifics which must be detailed. The Fighter vs Bomber Mix will be extremely important as the System MTBF will generally be reduced significantly when the unit is installed in a Fighter A/C.

- Tampering or mishandling

The units must be "sealed" before leaving the manufacturing facility. This can be accomplished by several methods, one of which is the crimping of a lead/wire seal which connects the unit dust cover to the front panel.
To monitor the temperature extremes to which the unit is subjected in the field, a piece of temperature sensitive tape can be applied to the inside of the unit dust cover. If excessive temperatures are consistently observed, compensation to the contractor may be warranted.

- Equipment usage (time)

The correctly written RIW contract will contain an Equipment Usage Clause. This clause will establish the number of hours per month the Service intends to use the

	equipment. The hours per month will be "banded" by a upper and lower limit. If the equipment monthly usage falls outside of the upper limit, financial compensation is due the contractor as the equipment will have accumulated excessive hours during the warranty. If, however, the usage is less, the contractor will be required to refund a portion of the warranty payment. To effectively formulate the hours of usage per month the equipments design should provide for an "Elapsed Time Indicator" (ETI). Without the availability of the ETI, the hours of usage per month will be extremely difficult if not impossible to calulate.
• Outyear costs	The contract must include, as protection for both parties, a clause which allows for price adjustment based on abnormal cost escalation. This clause should utilize a "Price Index" which is fair to both parties and closely represents the equipment under contract.
Government Risks	Recommendations
• RIW price	To ensure that an excessive price is not paid for the system utilizing an RIW concept, the Government must have sufficient contractors bidding on the job to provide for maximum competition. Additionally, a thorough analysis of the LCC utilizing Service maintenance must be accomplished which provides a baseline for the evaluation of the contractor bids.
• Administrative complexity	As suggested by the title, this category of risk is difficult to control and will continue to be a problem of some given magnatude during the entire program. The problems with introducing a new maintenance concept into the mainstream of an ongoing Service maintenance program is exremely difficult and sensitive. To minimize the impact and confusion of introducing an RIW program into the system the following actions are recommended:

1. Hold RIW briefings with user command personnel before the equipment reaches the field.
2. Ensure that each unit (LRU) in the system has an external "RIW Instruction Decal" which states the procedures to be followed.
3. Technical Manuals must be reviewed carefully to ensure the completness of all RIW instructions and procedures.
4. The Program Management Office and the contractor must work together as a team to minimize problems and confusion.

- Transition

The transition phase of the RIW program can be accomplished smoothly if approached with sufficient planning and cooperation. The Government may want to place a "Service Contract" with the contractor to assist during the transition phase. If the relationship between the parties has been one of cooperation during the five year warranty period, the transition period will simply be an extension of that relationship. Once again, planning and team work will be the real measure of success during this critical phase in the RIW program.

- Contractor performance

RIW contracts should be placed in the hands of reputable, reliable contractors. To place an RIW contract with a contractor who consistently fails to perform invites excessive costs, performance problems, and major schedule slipages for the program.

CONCLUSION

The RIW concept and philophy will and does work to the satisfaction of the Government and provides sufficient profits to industry if applied correctly.

There are, as shown, many RIW risks for both parties. However, methods and techniques are currently available to quanitify the risks being experienced. Risks are certainly not new and do exist any time the Government

and Industry enter into a business agreement. RIW is no different than any other business arrangement, risks must be assessed and planned for by both parties.

It is the writers opinion that RIW is a viable warranty concept that should and will be expanded upon in the coming years as experience and confidence is gained.

The true success for most RIW contracts will be measured by the ability and willingness of the parties involved to cooperate. For if maximum cooperation is evident, few problems will arise that cannot be worked out to the satisfaction of everyone concerned. When evaluating a maintenance concept, don't sell the RIW approach short, it may be just the approach that will turn your program into a real winner.

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